STRATEGIES FOR ENCOURAGING STUDENTS TO PERSIST ON CHALLENGING TASKS:

Some insights from work in classrooms

Anne Roche
<anne.roche@acu.edu.au>
Doug Clarke
<doug.clarke@acu.edu.au>
Peter Sullivan
<peter.sullivan@monash.edu>
Jill Cheeseman
<jill.cheeseman@monash.edu>

This article promotes the use of mathematically appropriate, engaging and challenging tasks to support learning that is worthwhile. The authors share insights from a three-lesson design experiment and the three tasks along with the results from their implementation are explored.

As part of a project called *Encouraging Persistence Maintaining Challenge* (EPMC), we have been working with teachers in the upper primary years, jointly planning lessons involving *challenging* tasks, and exploring strategies which teachers might adopt to increase student *persistence* on these tasks.

Most curriculum guidelines in mathematics education stress the need for teachers to extend students' thinking, and to pose substantial, realistic and open-ended problems (e.g., City, Elmore, Fiarman & Teitel, 2009). The intention is to develop productive habits of mind in mathematics, such as persisting, thinking flexibly, applying past knowledge to new situations, and taking responsible risks (Costa & Kallick, 2000). Yet in previous projects we have found that teachers seemed reluctant to pose challenging tasks to students, and students seemed to resist engaging with those tasks and exerted both passive and active pressure on teachers to over-explain tasks or to pose simpler ones (Sullivan, Clarke & Clarke, 2013).

Pogrow (1988) warned that by protecting the self-image of under-achieving students through providing them only "simple, dull material" (p. 84), teachers limit the development of self-confidence. He maintained that it is only through success on complex tasks that are valued by the students and teachers that such students can achieve confidence in their abilities. There will be an inevitable period of struggle while students begin to grapple with problems, but Pogrow asserted that this "controlled floundering"

is essential for students to begin to think at higher levels.

In sharing our experiences in the EPMC project, and the insights which have emerged so far, we draw upon a small three-lesson design experiment (e.g., Kelly, 2003) at Years 5 and 6. The mathematical focus of the three lessons was on interpreting maps, including understanding and applying a coordinate system to specify locations, using map scales to find the distances between landmarks, using knowledge of compass bearings to locate landmarks, and using and interpreting keys or legends.

Determining the distances between landmarks requires an understanding of the scale provided on the map and the use of proportional reasoning. In the tasks discussed below, this could be determined in several ways, such as by counting grid squares in a horizontal or vertical direction between landmarks, by using some indirect measure such as a ruler to measure the distance in a straight line on the page and convert this measure to an actual distance on the map, or using a piece of string to determine the distance of a non-straight path on the page and converting this length to an actual distance on the map. In particular, the use of map scale within the lessons discussed in this article was anticipated to be the most challenging part for which persistence would therefore be required.

There has been some research on student use of coordinate systems. Blades and Spencer (1989) noted that many young children by the age of four can use a coordinate reference system, and by age six are successful in tasks requiring an understanding of grid references. However, Battista (2007) also suggested that having students locate points is not enough; students must also analyse distances between points and determine these distances from coordinates. Sullivan et al. (2013), in discussing a task involving map scale, suggest that students in the middle grades are rarely asked to either create and/or use a scale.

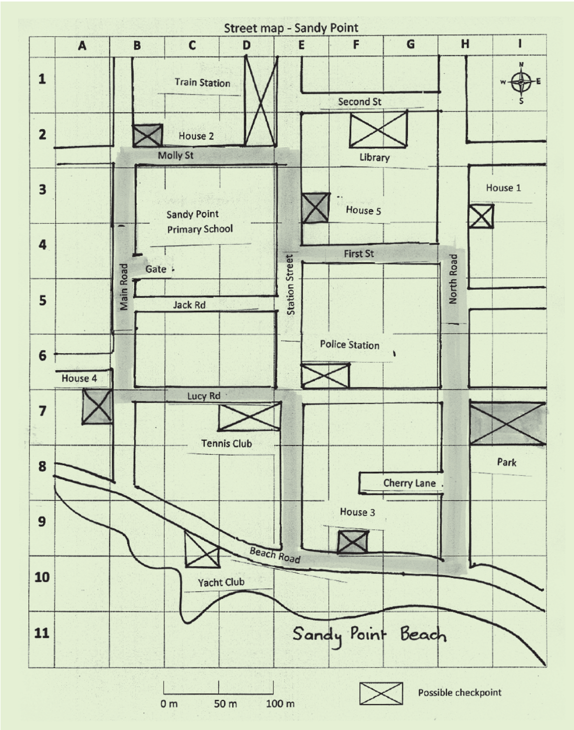
The setting and data collection

We believe that a carefully designed sequence of tasks has the potential to help learners to develop important mathematical ideas (Simon & Tzur, 2004). The three lessons were developed and piloted in other schools by the first author, prior to their use in Holy Spirit Primary School (North Ringwood, Victoria). At Holy Spirit, the first author taught the lessons to one Grade 5/6 class, while another teacher, Marianne, observed. Marianne taught the lessons to her own students the following day, while the two authors observed, collecting video and audio data and field notes on aspects of challenge and teacher behaviours that might assist student persistence. This two-part approach was taken so that Marianne would be comfortable with the mathematical intentions of the lesson and have a sense of how the lesson might play out before teaching it to her own class.

It is the lessons taught by Marianne which form the basis of the study. The authors prepared a written assessment, focusing on relevant content. This assessment was administered two weeks before the teaching sequence, one week after the three lessons, and then six weeks after the teaching had been completed.

The three lessons

In this section, we give a brief overview of the three lessons.



Lesson 1: Sandy Point Fun Run (Roche, 2013)

In this activity, students create a fun run (see a student work sample in Figure 1). The instructions to the students are that it must begin at the gate of Sandy Point Primary School, and end at the same gate (marked on the map). It must be between 1 and 2 kilometres long and must stop at exactly five out of the eleven checkpoints marked on the map. The students record on a separate table the progressive distance along the route, and the name and location of the checkpoints, (including the grid coordinates, the street name and the side of the street on which it is located; e.g., east side of Main Street). The scale on the map indicates that each square is 50 metres wide, meaning that 2 centimetres on the map is 50 metres in reality.

Lesson 2: Waratah State Forest

In this activity, the students complete a map of a State Forest, where only four landmarks are provided: the lookout, the walking track, the car park and the picnic area (see Figure 2). The key has missing icons for four other landmarks: the lake, the waterfall, Clancy's tree and the camping ground. These missing icons must be designed by the students and added to the key and the appropriate place on the map. From the lookout, there is a circular sign on which there are directions and distances to the missing landmarks which provide the information students need to locate them. The students are asked to place the circular sign (a laminated circle, 9.5 cm in diameter) onto the map in the appropriate orientation. Students also answer questions about their completed map such as: What direction is the camping ground from the lookout? Approximately what distance is it from the picnic area to the waterfall along the track?

Figure 1. Student work sample of Sandy Point Fun Run (Lesson 1).

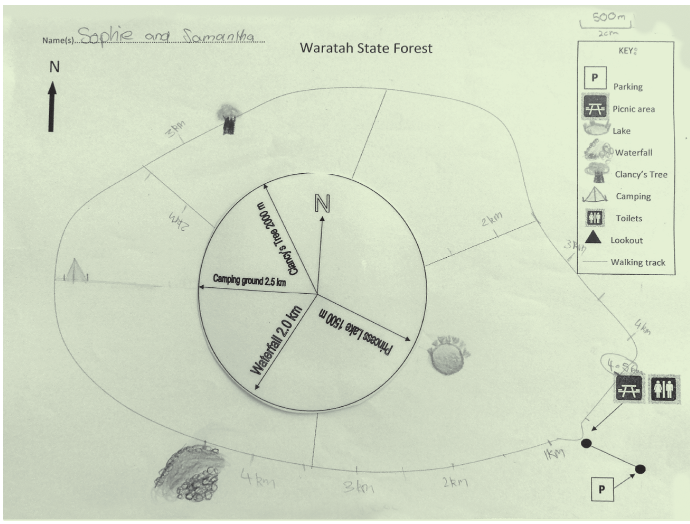


Figure 2. Students' work sample for Waratah State Forest (Lesson 2).

Figure 3. The legend/key has missing coordinates (Lesson 3).

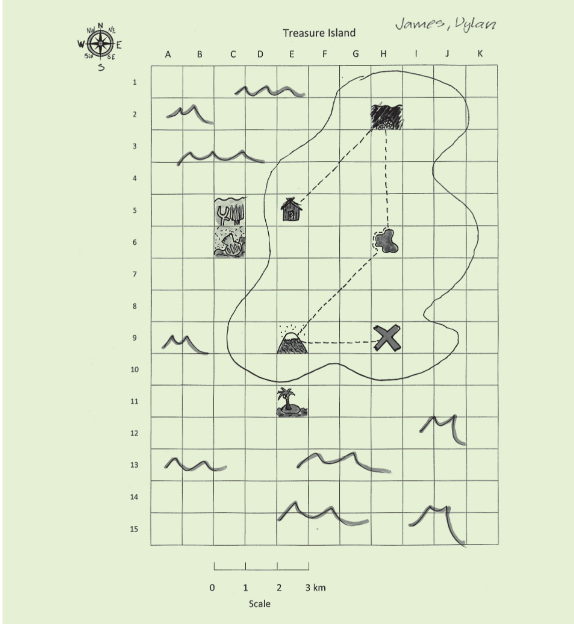


Figure 4. One pair's work sample for Treasure Island (Lesson 3).

Lesson 3: Treasure Island

In this activity, the students recreate a map of a 'treasure island'. Grid coordinates of the landmarks are provided (some partial, see Figure 3), as well as a story of two pirates and their journey in search of treasure.

These provide important information from which the students recreate the map of the island, outline the path the pirates take, and determine the location of the hidden treasure (see Figure 4). Along the way, the students use compass directions and map scale to determine the direction and distances between landmarks.

One of the greatest challenges for students in Treasure Island was the openness of the task. Some students struggled to come to terms initially with the fact that the location of Polly's Reef, for example, was not fixed, and that various decisions they made (e.g., the size of the lake) might affect the locations of various other landmarks.

What did we learn about the tasks, the level of challenge, and teacher actions to encourage persistence?

The EPMC project has involved four different schools to date, and we have developed a list of suggested strategies drawing upon what the research team and teachers are learning together across the schools. A detailed list can be found in Sullivan, Clarke, Michels, Mornane and Roche (2012). There were, however, two particular aspects which emerged strongly from the three lessons outlined above, and these are now discussed.

- *Tasks are chosen which have the potential to engage students in worthwhile, challenging and interesting mathematics.*

  All three lessons were rated by the teacher and students in surveys and interviews as engaging but challenging. Struggle is important for students if real learning is to take place. As Hiebert and Grouws (2007) noted, "we use the word *struggle* to mean that students expend effort to make sense of mathematics, to figure something out that is not immediately apparent. We do *not* use *struggle* to mean needless frustration or extreme levels of challenge created by nonsensical or overly difficult problems" (p. 387). When interviewed, the focus students highlighted challenges such as using the scale to determine actual distances, measuring distances along a curve, and dealing with the openness of some tasks (e.g., determining the location of the treasure in Treasure Island which could depend upon assumptions made from earlier clues). The teacher and researchers noticed challenges such as the mechanics of using a ruler appropriately and conversion of units.

- *The ways of working are explained to the students, including the type of thinking in which they are expected to engage and what they might later report to the class.*
  If students are to attack problems with confidence and to persist, it is important that they are clear about what is expected of them. With the class on the mat and engaging visuals to 'hook' the students, the teacher gave a brief summary of the work ahead, the time allocated to it, and expected outputs, particularly in relation to what would be recorded. The teacher made comments such as: "When you come back, I will be really interested in how you used the scale to work out the distance, because that's the challenging part." The students then commenced work, usually in pairs, with the expectations clear in their minds. During interviews, the classroom teacher highlighted that explaining the ways of working was one that she was specifically working to improve in her teaching.

In audiotaped interviews with Marianne after each lesson, there were two recurring themes: her greater emphasis on holding back and listening to students more, and the struggles in which her students were involved. She was finding that holding back meant that she was less likely to intervene inappropriately, and was more likely to really understand her students' thinking. Although while she noticed students were struggling, it was a positive struggle where students were wrestling with important ideas, while not being discouraged.

Some encouraging assessment data

As mentioned earlier, students completed a pre-test of relevant content, and then the same test as a post-test and a delayed (six weeks) post-test. There were 16 items (three involving grid coordinates, five involving compass directions, and eight involving scale). We were most interested in the improvement on the two items which proved most challenging on the pre-test. The first of these involved determining the distance travelled between three towns (from A to B to C to A, see Figure 5) using a scale. Only four out of 26 students were successful on the pre-test, but this increased to 10 on the post-test.

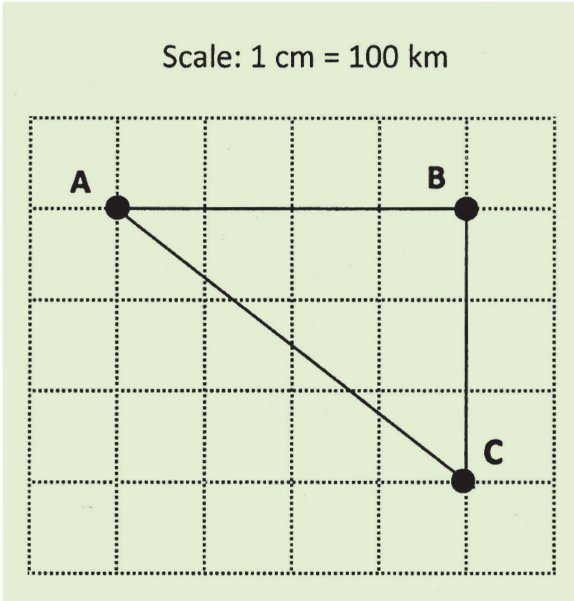


Figure 5. Test item in which students are required to determine the distance from A to B to C to A.

The second task involved writing or drawing a scale for the map shown in Figure 6, given the actual distance (500 m) between the flagpole and the lookout.

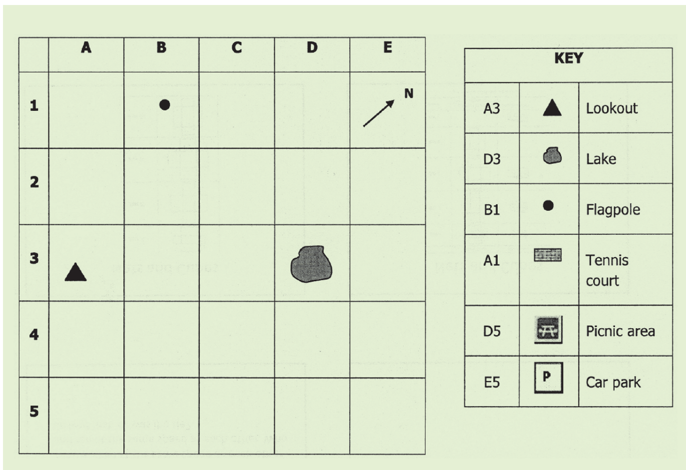


Figure 6. Test item in which students determine an appropriate scale given the actual distance between two landmarks on the map.

Before the three lessons, only three students out of 26 correctly drew a scale, with six redrawing part of the map (see examples in Figure 7) and four leaving the item blank.

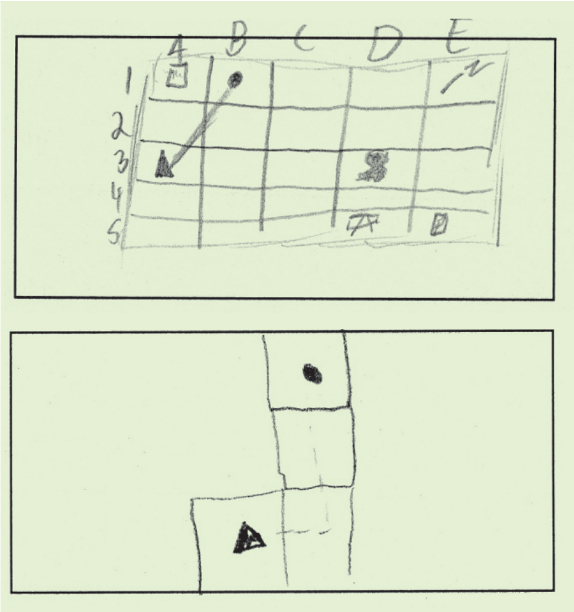


Figure 7. Some student responses to the 'draw a scale' test item in the pretest.

However, on the post-test, 14 students drew a correct scale (see examples in Figure 8) and no one redrew part of the map or left the item blank.

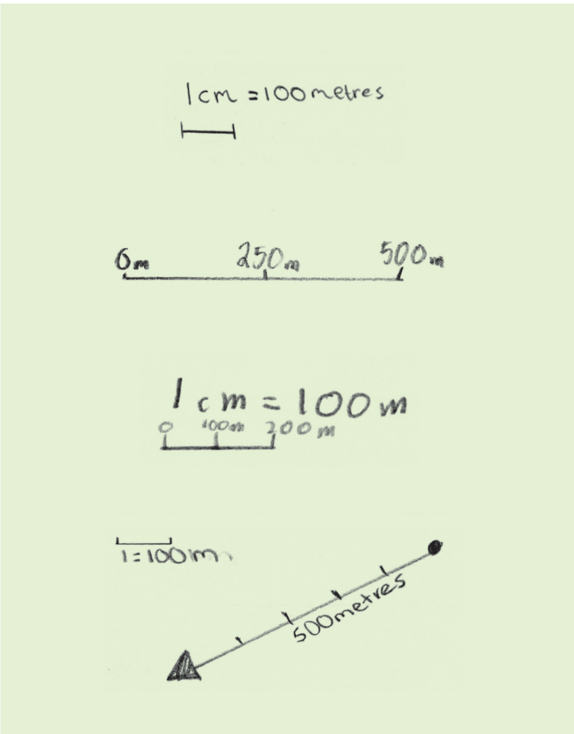


Figure 8. Some student responses to the 'draw a scale' test item in the post-test.

We were most encouraged that the work on challenging tasks yielded considerable improvement on the most difficult items.

Conclusion

For worthwhile learning in mathematics, students need mathematically appropriate, engaging and challenging tasks. At the same time, the decisions which the teacher makes (in planning, and 'on the run') can make a considerable difference in how the task plays out, the level of persistence shown by students, and the resulting learning, cognitively and affectively.

Acknowledgement

We acknowledge gratefully the support of the principal, Peter Camilleri, of Holy Spirit Primary School (North Ringwood) and Marianne Condon, Year 5/6 teacher. It was an absolute privilege to work in their school, and we learned so much.

References

Battista, M. T. (2007). The development of geometric and spatial thinking. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 843–908). Charlotte, NC: National Council of Teachers of Mathematics.

Blades, M. & Spencer, C. (1989). Young children's ability to use coordinate references. *The Journal of Genetic Psychology, 150*(1), 5–18.

City, E. A., Elmore, R. F., Fiarman, S. E. & Teitel, L. (2009). *Instructional rounds in education.* Cambridge, MA: Harvard Educational Press.

Costa, A. L. & Kallick, B. (Eds). (2000). *Integrating and sustaining habits of mind.* Alexandria, VA: Association for Supervision and Curriculum and Development.

Kelly, A. (2003). Research as design. *Educational Researcher, 32*(1), 3–4.

Simon, M. & Tzur, R. (2004). Explicating the role of mathematical tasks in conceptual learning: An elaboration of the hypothetical learning trajectory. *Mathematical Thinking and Learning, 6*(2), 91–104.

Pogrow, S. (1988). Teaching thinking to at-risk elementary students. *Educational Leadership,* 79– 85.

Roche, A. (2013). Sandy Point fun run: A context for understanding and using scale. *Australian Primary Mathematics Classroom 18*(3), 35–40.

Sullivan, P., Clarke, D., Michels, D., Mornane, A. & Roche, A. (2012). Supporting teachers in choosing and using challenging mathematics tasks. In J. Dindyal, Lu Pien Cheng & Swee Fong Ng (Eds), *Mathematics education: Expanding horizons* (Proceedings of the 35th Annual Conference of the Mathematics Education Research Group of Australasia, pp. 688–695). Singapore: MERGA.

Sullivan, P., Clarke, D. & Clarke, B. (2013). *Teaching with tasks for effective mathematics learning.* New York: Springer.